property of the material 40 in Kumar. However, Applicants respectfully disagree, for several reasons. Note first that the material 40 in Kumar is taught as being thin, in order to maximize deposition thruput. That is because (as shown in Fig. 7) the material 40 is deposited using a focused ionized metal cluster beam deposition. As discussed at Col. 5, lines 45-52 of Kumar:

"...However, the first metallic bumps 40 are deposited in a thin form in order to speed up the fabrication of bumps. That is, the first metallic bumps 40, for example only, may be 500 angstroms thick of gold which are formed as in Fig. 3 by depositing the bumps 40 by a focused cluster beam. Because of the thinness of the first metallic bumps 40, they can be quickly fabricated over all of the pads 14a."

Cluster beam tools typically have low thruput. The point of Kumar's teachings is to address this problem by using the tool to make a thin deposition. Applicants respectfully submit that such language would tend to teach away, rather than toward, the invention. The emphasis of these teachings is the deposition of a thin bump layer, not on depositing a layer thick enough to prevent penetration of materials from the solder.

Kumar is not concerned with the issue of material penetrating from the solder for a simple reason - the combination of materials used in Kumar would not have this problem. As discussed by Applicants at pages 2-3 of their specification, tin diffusing from solder does not react significantly with aluminum; it does with copper. In Kumar the pad 14 is made out of aluminum. Thus, there is no need for the metal 40 to be designed so as to prevent tin penetration into aluminum 14, since aluminum is not nearly as reactive as copper. Moreover, even if a person of ordinary skill in the art were motivated to replace the aluminum pad 14 in Kumar with copper, the thin material 40 would not be sufficient to prevent the formation of tin-copper intermetallics.

Typically barrier materials prevent penetration of materials into underlaying layers. As pointed out in their specification, the present inventors have found that solder materials such as tin can

penetrate through barrier layers. None of the references of record teach the use of any additional material to prevent penetration of materials from solder. All the references of record teach that a barrier layer is sufficient for the job; other layers are used for other purposes. In the invention, in order to prevent penetration of materials that can penetrate through barrier layers, the inventors utilize a pad that is made out of the same material as the underlaying materials (i.e. copper). Therefore the pad forms the same type of intermetallics that would be formed in the underlaying layers; as such, the pad prevents these intermetallics from forming in the underlaying layers. None of the references of record suggest this.

In the Office Action, the Examiner comments on the arguments set forth in the previous Amendment. The Examiner maintains that the arguments are inapplicable because in his rejection he is simply substituting the copper metal plug and the underlaying barrier layer of Zhao for the aluminum metal plug and underlaying barrier layer of Kumar. Applicants respectfully submit that such a substitution would not occur to a person of skill in the art giving full credence to the teachings of Zhao.

The law of obviousness does not support picking and choosing from references only those teachings that support a rejection; rather, each reference must be considered as a whole for what it would fairly suggest to a person of skill in the art. Here, Zhao would not suggest placing a copper plug directly beneath and in contact with a solder ball; if anything, Zhao would tend to teach away from such a combination.

As stated in the remarks section of the previous Amendment, Zhao teaches the inclusion of a diffusion barrier above the second layer of copper. The teaching of the diffusion barrier is key to the overall teachings of Zhao; specifically, the patent says "[s]ince copper diffuse/drift (sic, diffuses/drifts) easily in inter-level-dielectric (ILD) materials, copper interconnect structures must be encapsulated by diffusion barrier layers...Typically, the use of diffusion barrier material to encapsulate copper is not limited to the copper-ILD interface, but also to interfaces with other

metals as well. Thus, copper encapsulation techniques are also used to isolate coper interconnect structures....from overlying metal layers where these metal layers are formed from other than copper..." (Col. 2, lines 8-29; see also Col. 8, lines 8-31), emphasis supplied. Thus, a person of ordinary skill in the art, in making this combination, would apply both the copper plug 23 and the barrier 24 of Zhao, rather than simply the plug 23 and the underlaying barrier. To do so as the Examiner suggests would be to IGNORE the plain teachings of Zhao. Applicants respectfully submit that Zhao teaches away from, rather than toward, the invention (wherein, as shown in Fig. 2, the solder ball 25 is disposed directly on the copper layer 24; the point of the copper layer immediately below the solder ball is to consume impurities, not to be protected from them (c.f. page 10, lines 2-7 of the present specification)). Given that, and given the changes made to the independent claims to further distinguish from Kumar and the other references of record, Applicants respectfully submit that the rejections of record have been traversed.

As pointed out in the previous Amendment, Applicants respectfully submit that neither the Chang et al reference (USP 5,048,744) nor the Havemann reference (USP 6156651) teach or suggest structures that would address the shortcomings of the Kumar-Zhao combination as discussed above. Chang et al simply teaches different barrier layers. In Havemann, whenever a copper metallization is utilized, note it is capped with either a conductive barrier layer (note e.g. the front figure of the patent, copper 26 is capped by TiN layer 28) or a nonconductive encapsulant layer (note e.g. copper 52 is capped with a silicon nitride encapsulant 54). In all cases, Havemann teaches utilizing protective layers that prevent impurities from penetrating into the copper. Again, note that in the invention the point of the copper layer immediately below the solder ball is to consume impurities, not to be protected from them. As such, Applicants respectfully submit that Havemann teaches away, rather than toward, the invention, in that it teaches copper applications in which copper is isolated from potential contaminants, not used to help consume them.

Applicants further respectfully request entry of the present amendment. The notions added by amendment to the independent claims are analogous to the notions generally recited in claim 6,

now cancelled. Accordingly, no further consideration or search would be required to consider these notions other than considering the positions set forth in this Amendment, since analogous notions were previously considered and searched.

Accordingly, Applicants respectfully request entry of the present Amendment and passage of their subject application to issuance in view thereof. Should the Examiner have any comments, questions, or suggestions, please do not hesitate to contact the undersigned attorney at the telephone number and/or email address set forth below.

Respectfully submitted,
For: Howell et al.

By: _____
Mark F. Chadurjian
Reg. No. 30,739
Telephone: (802) 769-8843
Facsimile (802) 769-8938
Email: mchadurj@us.ibm.com

IBM Corporation, IPLaw Dept. 972E
1000 River Street
Essex Junction, VT 05452

Exhibit A

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Claims:

Cancel claim 4, without prejudice or disclaimer.

6. (Four times Amended) A metallurgical structure comprising:
a passivation layer;
a via through said passivation layer extending to a metal line within said metallurgical structure;
a barrier layer lining said via;
a metal plug in said via above said barrier layer, wherein said metal plug and said metal line comprise a same material, and wherein said metal plug, said barrier layer and said passivation layer form a planar exterior surface of said metallurgical structure; and
a solder bump formed on said planar exterior surface;
wherein said solder ball is in direct contact with said metal plug,
and wherein said metal plug forms sufficient intermetallics with elements diffusing from said solder bump so as to prevent said elements from penetrating through said barrier layer into said metal line.

13. (Four times Amended) [An integrated circuit structure comprising:
internal components within an exterior covering;
a via extending through said exterior covering to said internal components;
a barrier layer lining said via;
a plug in said via above said barrier layer, wherein said plug and said internal components comprise a same material, and wherein said plug and said barrier layer form a planar exterior surface of said integrated circuit structure; and
a connector formed on said planar exterior surface;
wherein said connector is in direct contact with said plug,
and wherein said metal plug forms sufficient intermetallics with elements diffusing from said solder bump so as to prevent said elements from penetrating through said barrier layer into said metal line.

23. (Amended) A metallurgical structure, comprising:
forming a first layer of copper on a substrate;
forming a barrier layer on said first layer of copper;
forming a second layer of copper formed on said barrier layer; and
forming a conductive structure that includes a given species, at least some of said given

species diffusing from said conductive structure, said second layer of copper having a thickness sufficient to form intermetallics with [at least partially consume] said species diffusing from said conductive structure, and to adhere to said conductive structure, so as to prevent said species from penetrating through said barrier layer into said first layer of copper.